Puzzling It Out
Collaborative Review Activity for Introductory Statistics

Instructor Guide

Developed by:
Miranda M. McIntyre, Ph.D.
Department of Psychology
California State University, San Bernardino

Summary

This activity incorporates high-impact practices to review and practice introductory statistics concepts. The exercises are inspired by "escape room" puzzle games. In small groups, students solve puzzles that require them to apply basic statistical knowledge and skills. The activity is designed to be a modular game in which each solution leads to an additional puzzle, but the materials can be adapted and customized to suit a variety of teaching strategies.

Materials

The materials include a set of 15 ready-to-use puzzles. The puzzles are identified by letter (A through O). They cover a range of topics from introductory statistics, including basic quantitative concepts, descriptive statistics, and inferential tests. The puzzles are arranged in the approximate order of coverage in most social science statistical courses, but they can be used in any order. These materials include:

- Blank puzzle files as printable student handouts
- Solution keys for instructors
- Index table identifying the puzzle topics and instructor preparation required

Classroom Use

This activity is designed for game-based collaborative learning. Research supports the benefits of peer learning relative to individual work (Johnson, Johnson, & Smith, 2007; Nokes-Malach, Richey, & Gadgil, 2015). Educational games in particular can boost student performance and foster positive attitudes toward learning (Cardozo, Miranda, Moura, & Marcondes, 2016; Luchi, Montrezor, & Marcondes, 2017; Plass et al., 2013; Sung & Hwang, 2013). Thus, this game may spark students' interest in statistics in addition to reinforcing their quantitative skills.

To use as a review activity, instructors should select a set of puzzles to use in the game. Each puzzle generally takes 5 to 10 minutes to solve depending on students' familiarity with the material. Instructors should determine the number and order of puzzles in advance of the activity, then prepare the materials accordingly.

Students should be arranged in 3- to 5-person teams. After passing out the first puzzle, instructors should actively monitor the groups and provide hints or other assistance when necessary. Each puzzle is designed to produce a solution in the form of a code or pattern that can be checked by the instructor. The correct solution "unlocks" the next puzzle in the sequence. Any number of puzzles can be used in the game, depending on classroom time limits.

This activity provides the greatest pedagogical benefit when students work collaboratively. Instructors should be wary of a competitive atmosphere that drives teams to solve the puzzles as quickly as possible. The game is most valuable when group members arrive at the solutions together by discussing potential answers and resolving their own errors. Teams that solve the puzzles quickly with little discussion (e.g., when an advanced student takes charge) will receive little benefit from the activity. Instructors can encourage collaboration by checking that all group members understand each solution before moving on.

Adaptations

In addition to the review game described above, the puzzle materials can be adapted in many forms. Alternative uses for these materials include:

- Using standalone puzzles during class to demonstrate a newly-learned concept
- As a "lecture launcher" at the beginning of class, using standalone puzzles to review previously-learned material and encourage practice
- As an individual take-home activity or assignment
- In electronic form, customizing the puzzles using QR codes, web addresses, or other digital tools to adapt the materials for online use
- As a model for students to create their own puzzles from the material

Additional Resources

Instructors who are interested in customizing the materials or designing their own puzzles may find the following resources valuable:

- Dr. Richard Landers' dataset generator for introductory statistics
  https://rlanders.net/dataset-generator/
- Lock Paper Scissors guide to escape room puzzles
  https://lockpaperscissors.co/ciphers-playbook
- Cipher Tools for generating simple codes
  http://rumkin.com/tools/cipher/
- dCode website with extensive coding tools
  https://www.dcode.fr/en

References

Cardozo, L. T., Miranda, A. S., Moura, M. J. C. S., & Marcondes, F. K. (2016). Effect of a puzzle on the process of students' learning about cardiac physiology. *Advances in Physiology Education*, *40*, 425-431.

Johnson, D. W., Johnson, R. T., & Smith, K. (2007). The state of cooperative learning in postsecondary and professional settings. *Educational Psychology Review, 19*, 15–29.

Luchi, K. C. G., Montrezor, L. H., & Marcondes, F. K. (2017). Effect of an educational game on university students' learning about action potentials. *Advances in Physiology Education*, *41*, 222-230.

Nokes-Malach, T. J., Richey, J. E., & Gadgil, S. (2015). When is it better to learn together? Insights from research on collaborative learning. *Educational Psychology Review*, *27*, 645-656.

Plass, J. L., O'Keefe, P. A., Homer, B. D., Case, J., Hayward, E. O., Stein, M., & Perlin, K. (2013). The impact of individual, competitive, and collaborative mathematics game play on learning, performance, and motivation. *Journal of Educational Psychology*, *105*, 1050-1066.

Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education*, *63*, 43-51.

Puzzle Index

Puzzle	Topic/Learning Outcome	Pages	Preparation
A	Identifying variable level of measurement	Multiple	None
B	Calculating measures of central tendency (mean, median, mode)	Single	None
C	Identifying statistical notation (statistics vs. parameters)	Single	None
D	Understanding frequency distributions, normality, modality, and skewness	Multiple	None
E	Calculating z-scores from raw scores, using the *z* distribution	Multiple	None
F	Distinguishing between null and alternative hypotheses	Multiple	None
G	Identifying Type I and Type II error	Single	None
H	Determining statistical significance, interpreting test values and critical values	Multiple	None (Color print helps)
I	Identifying t-tests, calculating degrees of freedom	Single	Cutouts
J	Calculating degrees of freedom, locating critical values using a t-table	Multiple	Separate envelopes
K	Identifying types of group comparisons	Single	None
L	Interpreting correlation coefficients and scatterplots	Multiple	Cutouts
M	Interpreting post hoc results for one-way ANOVA	Multiple	None
N	Identifying main effects and interactions for two-way ANOVA	Multiple	Cutouts
O	Determining statistical procedures based on research questions	Single	None

Goal: Escape from the grid by finding the correct path to the outside ring

Rules: From the **START** position, you will make 8 moves

You can move within a ring or move closer to the outside

You can move to adjacent squares, but not diagonally

You cannot re-enter a ring to move back toward the center

1	2	3	4	5	6	7
I	O	I	N	R	N	R
R	N	R	O	I	O	I
I	O	I	N	R	N	R
R	N	R	**START**	O	I	O
O	I	O	I	N	R	N
N	R	N	R	O	I	O
O	I	O	I	N	R	N

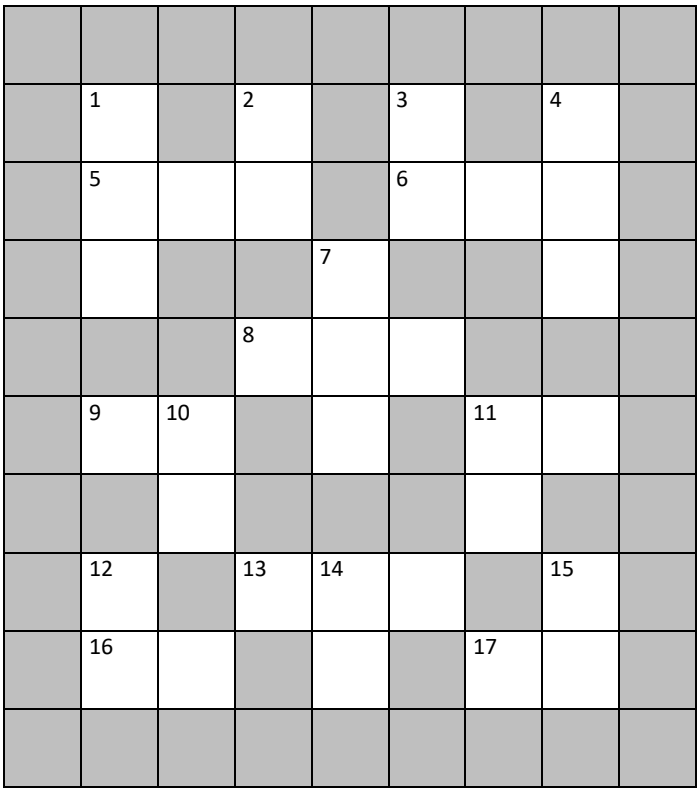
19 18 17 16 15 14 13 — 24 — 23 — 22 — 21 — 20 — 8 — 9 — 10 — 11 — 12

Where did you exit the grid? Square # _____

N = Nominal variable
O = Ordinal variable
I = Interval variable
R = Ratio variable

Which level of measurement?

1st move	Eye color (brown, blue, green, etc.)	
2nd move	Annual salary (in $)	
3rd move	Olympic medal (gold, silver, bronze)	
4th move	Academic major (psychology, history, chemistry, etc.)	
5th move	IQ score (120, 90, 140, etc.)	
6th move	Distance travelled (in meters)	
7th move	Level of education (high school, bachelor's, master's, etc.)	
8th move	Favorite music genre (pop, country, rock, etc.)	

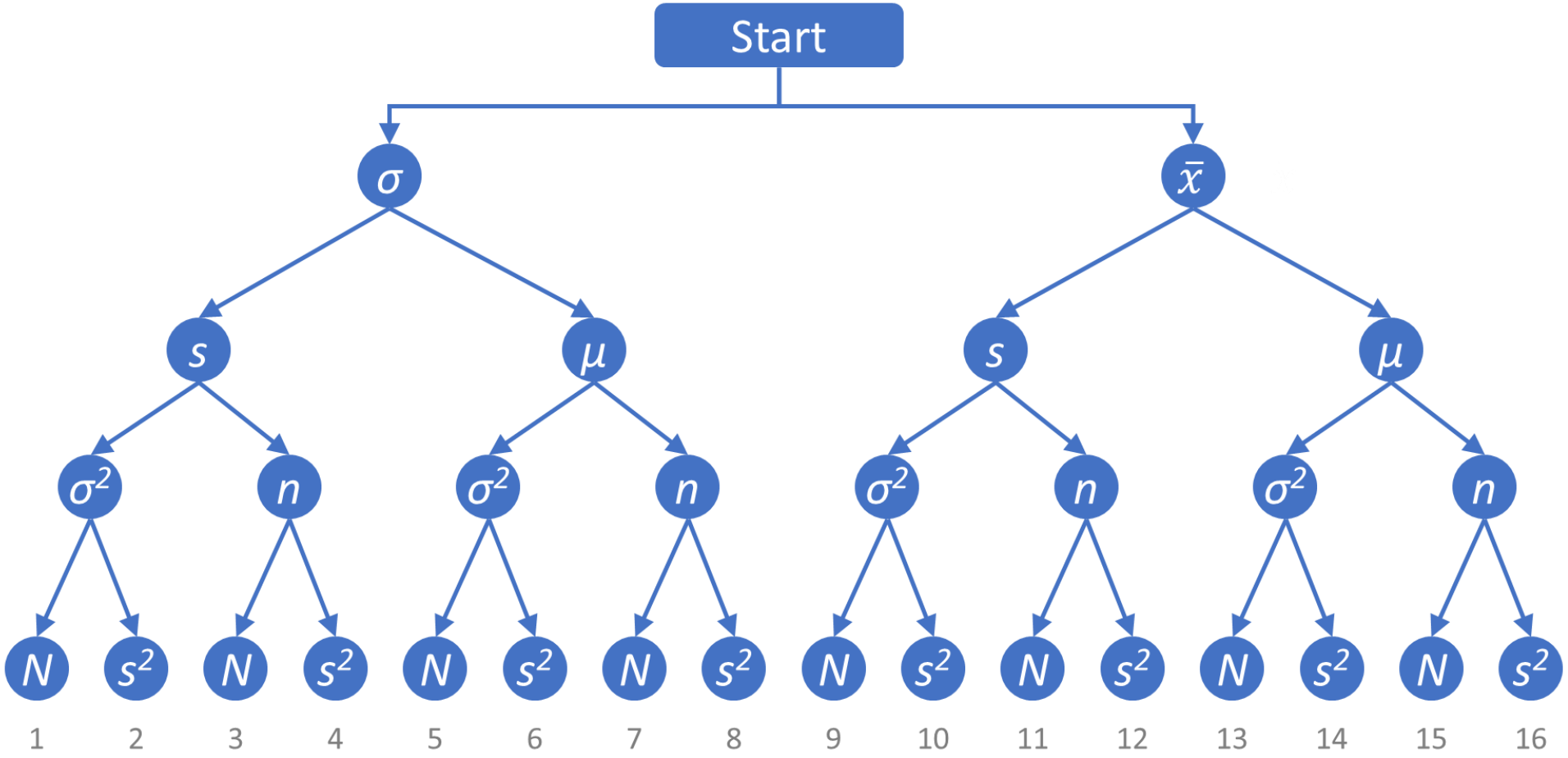


Down

1. Mean of 155, 120, 77, 106, 182
2. Mode of 25, 15, 10, 15, 10, 25, 10
3. Mean of 60, 56, 44, 45, 54, 59, 53
4. Median of 867, 473, 531, 122, 755, 804
7. Median of 372, 105, 986, 264, 246, 139
10. Mode of 20, 22, 16, 16, 14, 19
11. Mean of 26, 53, 37, 24, 37, 51
12. Median of 18, 12, 14, 16, 14, 19, 11
14. Mean of 0, 0, 0, 25, 75, 200
15. Mode of 51, 47, 53, 48, 47

Across

5. Median of 280, 160, 230, 310, 100
6. Median of 490, 80, 357, 291, 541, 280
8. Mode of 959, 595, 959, 595, 959
9. Mode of 11, 15, 31, 11, 23
11. Mean of 30, 31, 32, 33, 34
13. Mode of 157, 256, 0, 177, 256
16. Median of 100, 2, 15, 37, 73, 55
17. Mean of 11, 17, 21, 17, 18, 18



Following the symbols that represent **sample** statistics leads to path #: _____

Following the symbols that represent measures of **variability** leads to path #: _____

Following the symbols that represent **population** parameters leads to path #: _____

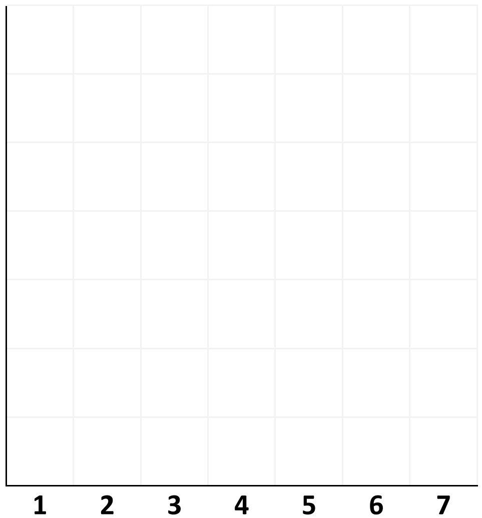
Match each set of sample values to its frequency distribution

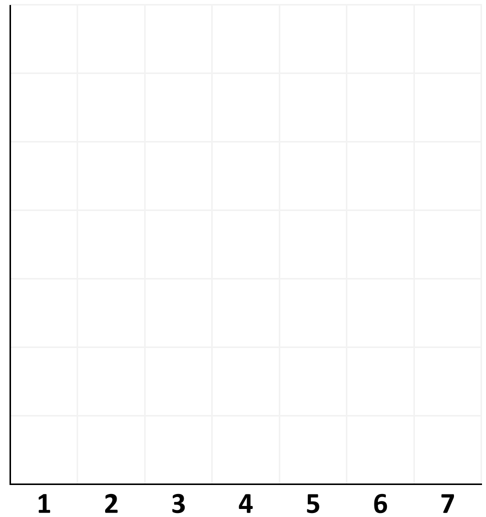
(You can use the blank charts to help visualize the samples)

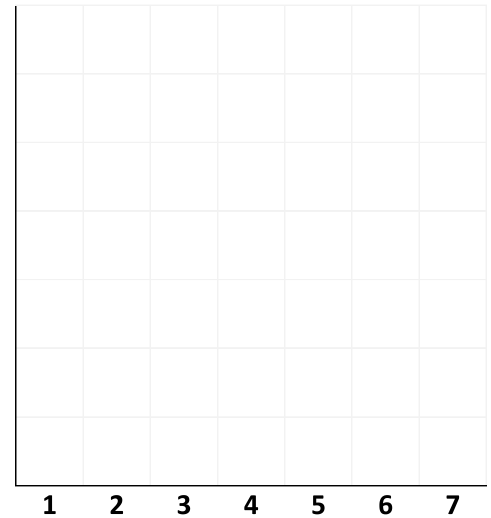
Sample	Sample values (*n* = 16)
A	6, 4, 1, 5, 5, 6, 7, 7, 3, 4, 6, 5, 5, 2, 3, 4
B	6, 3, 7, 5, 2, 2, 5, 6, 3, 4, 4, 3, 5, 4, 4, 1
C	2, 5, 4, 4, 3, 6, 3, 6, 3, 1, 1, 2, 2, 1, 5, 1
D	2, 4, 7, 4, 7, 1, 6, 1, 2, 4, 1, 7, 5, 1, 4, 7
E	6, 4, 5, 2, 6, 6, 1, 2, 7, 2, 3, 5, 2, 4, 1, 6
F	2, 4, 5, 4, 4, 2, 3, 5, 3, 2, 3, 2, 4, 5, 3, 5

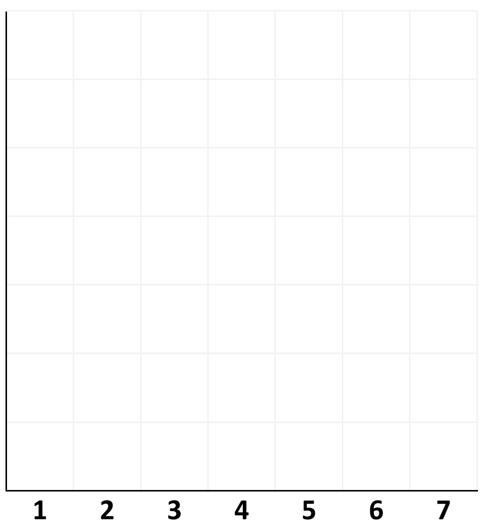
Which Distribution?
Positively skewed
Negatively skewed
Uniform
Bimodal
Trimodal
Unimodal normal

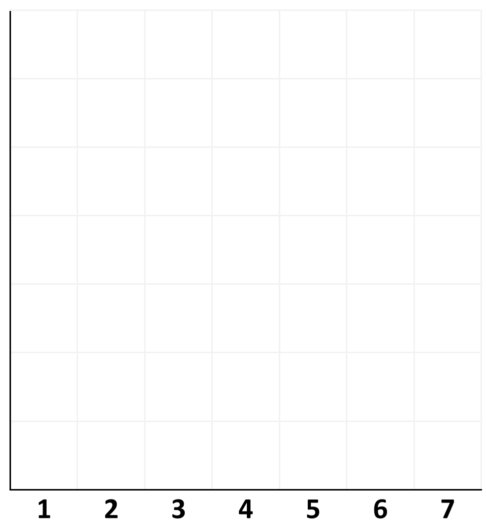
Puzzle D

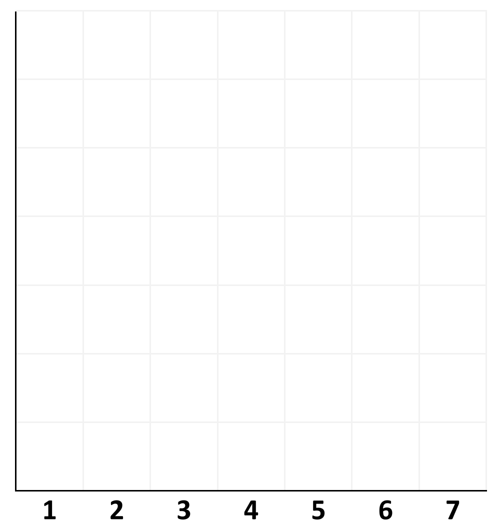




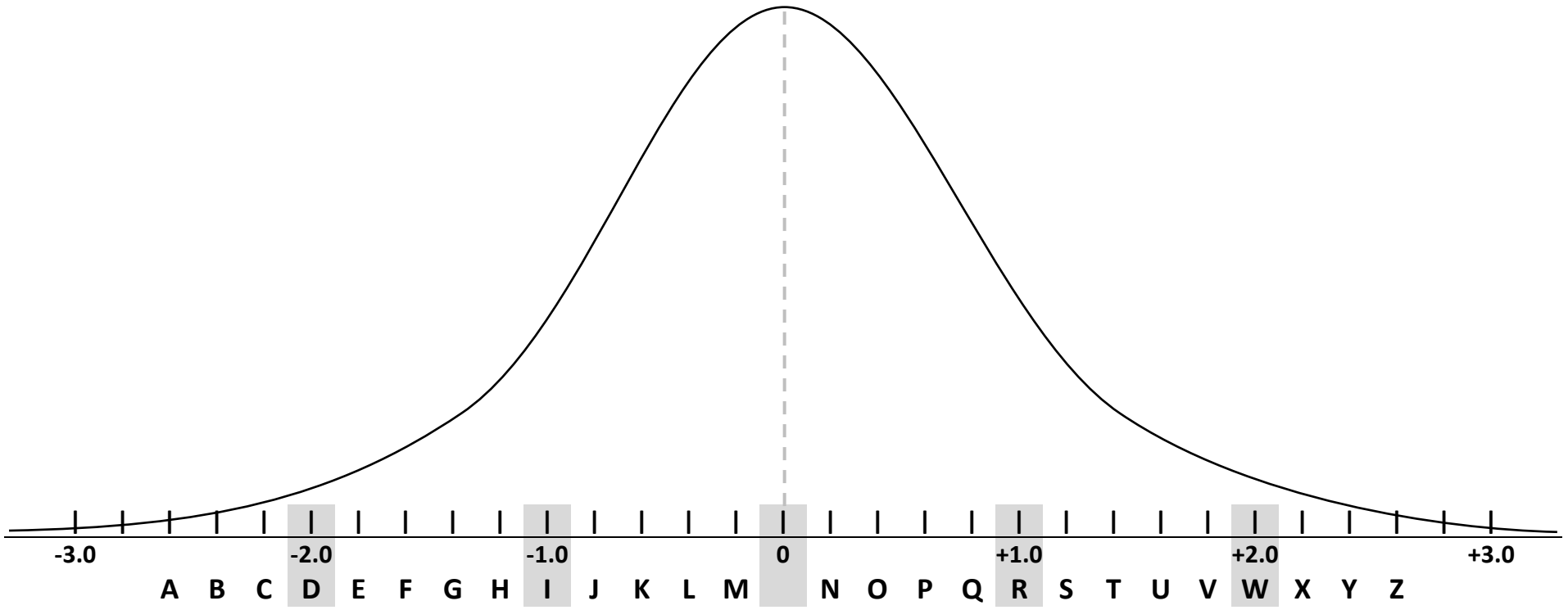








Puzzle E



Code word: ___ ___ ___ ___ ___ ___ ___ ___ ___

#	Raw Score	Z-Score
1	The average number of steps people walk per day is 5,000 (SD = 1,000 steps). Amy walks 6,000 steps.	
2	The mean height of American men is 5'9" (69 inches), with a standard deviation of 3 inches. Bob is 61.2 inches tall.	
3	A company manufactures products that weigh 350 grams (SD = 5 grams). A customer receives a product that weighs 351 grams.	
4	An average bag of candy contains 60 pieces (SD = 3 pieces). Derek buys a bag of candy that contains 54 pieces.	
5	A new car model has an average fuel economy of 43 miles per gallon and a standard deviation of 1.5 MPG. A test-driven vehicle gets 43.6 MPG.	
6	The average salary at a company is $45,600 (SD = $6,700). A specific employee makes $44,260.	
7	The average house in a neighborhood has 3.5 bedrooms (SD = 1.5 bedrooms). One family's house has 2 bedrooms.	
8	A class takes an exam with an average score of 78% (SD = 7%). Maria's exam score is 96.2%	
9	The average cup of coffee contains 95 mg of caffeine, with a standard deviation of 15 mg. Dan's cup contains 68 mg of caffeine.	

Type	Hyp. 1	Hyp. 2	Hyp. 3	Hyp. 4	Hyp. 5	Hyp. 6	Hyp. 7	Hyp. 8
Non-directional Null	**H**	**A**	**G**	**E**	**L**	**F**	**O**	**D**
Directional Null	**P**	**I**	**W**	**O**	**E**	**R**	**A**	**N**
Non-directional Alternative	**T**	**E**	**L**	**U**	**R**	**D**	**U**	**R**
Directional Alternative	**B**	**O**	**E**	**A**	**P**	**L**	**E**	**L**

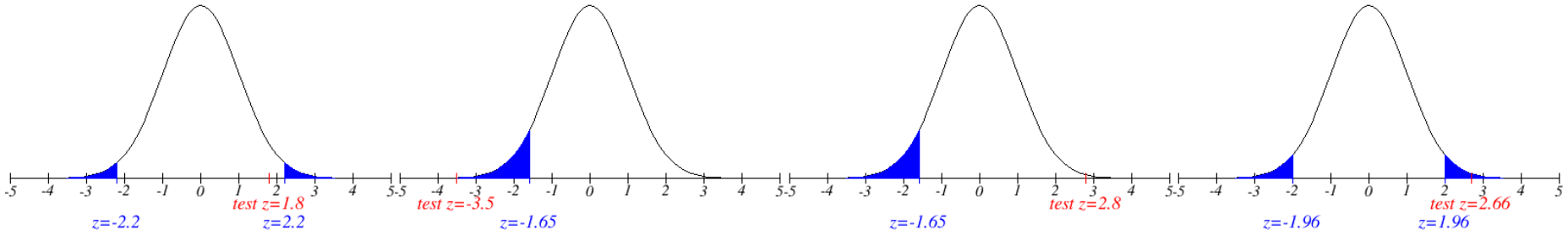
Code Word: ____ ____ ____ ____ ____ ____ ____ ____

Hypothesis 1	Age is unrelated or positively related to memory performance
Hypothesis 2	A new medication improves patients' symptoms
Hypothesis 3	The treatment group will not perform better than the control group
Hypothesis 4	Attending tutor sessions does not affect students' grades
Hypothesis 5	Noise level will influence customer satisfaction
Hypothesis 6	Daily temperature is unrelated to urban crime rates
Hypothesis 7	Education level has an effect on household income
Hypothesis 8	A proposed law will decrease traffic accidents

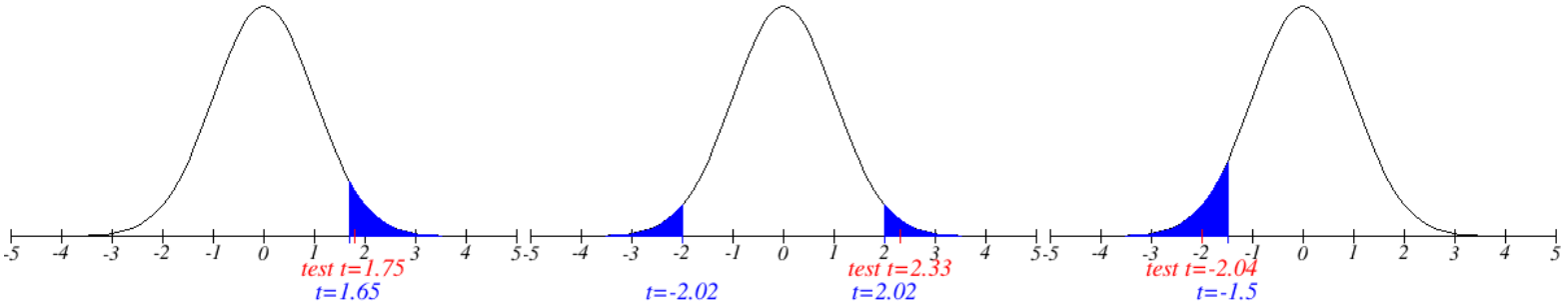
Type I Error	Type II Error	
☐	☐	A pharmacologist concludes that a new depression drug is an effective treatment, but it actually does nothing
☐	☐	An economist predicts that a company's stock will be stable, but the stock skyrockets
☐	☐	A water treatment plant determines that a water source is safe to drink, but the water is toxic
☐	☐	An economist predicts that a company's stock will skyrocket, but the stock does not change
☐	☐	A water treatment plant determines that a water source is toxic, but the water is safe to drink
☐	☐	A pharmacologist concludes that a new depression drug is ineffective, but it actually reduces depression symptoms

Puzzle H

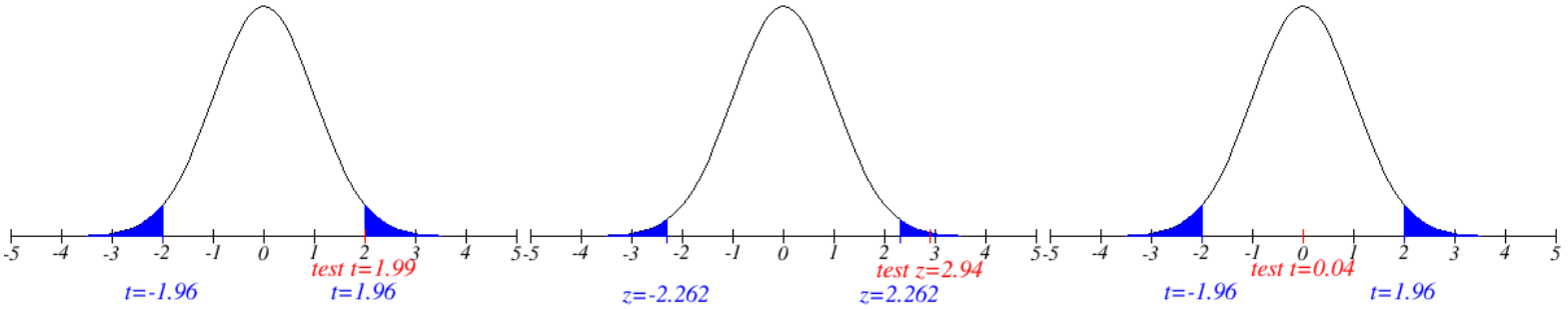
1



2



3

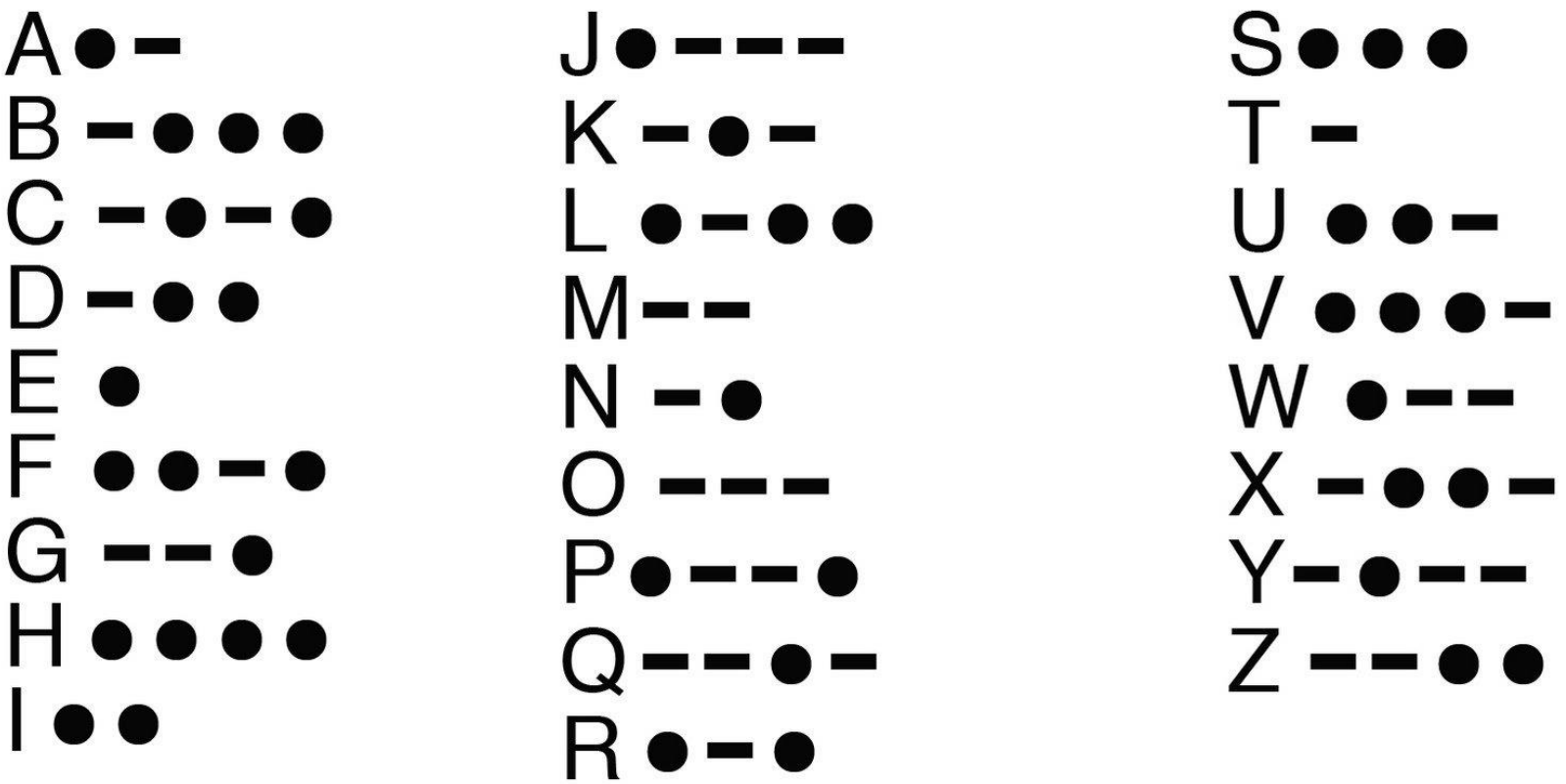


_____ _____ _____

1 2 3

Significant ●

Not Significant —



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

	df	Code
Comparing health for 20 cancer patients before and after treatment		
Comparing IQ of 12 women and 10 men		
Comparing life expectancy in 1910 and 2010 for two countries		
Comparing marital satisfaction in 21 couples (42 spouses total)		
Comparing blood pressure in 6 vegans and 15 meat-eaters		

Connect the critical values for the tests below
to create a **shape** on your t-table

Independent t-test comparing two groups of N = 16 each, two-tailed $\alpha = .02$

Dependent t-test with 31 pairs of participants, one-tailed $\alpha = .05$

Independent t-test comparing two groups that each have 12 participants, one-tailed $\alpha = .025$

Dependent t-test with 46 spouses analyzed in pairs, two-tailed $\alpha = .20$

Once you have identified the shape,
open the corresponding envelope!

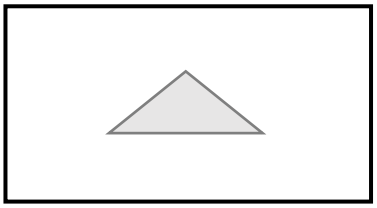
TABLE A-3 *t* Distribution: Critical *t* Values

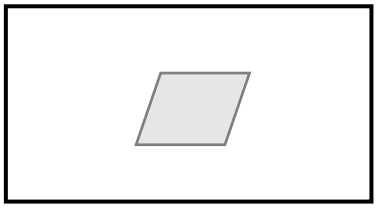
	Area in One Tail				
	0.005	0.01	0.025	0.05	0.10
Degrees of Freedom	Area in Two Tails				
	0.01	0.02	0.05	0.10	0.20
1	**63.657**	31.821	**12.706**	6.314	3.078
2	**9.925**	6.965	**4.303**	2.920	1.886
3	**5.841**	4.541	**3.182**	2.353	1.638
4	**4.604**	3.747	**2.776**	2.132	1.533
5	**4.032**	3.365	**2.571**	2.015	1.476
6	**3.707**	3.143	**2.447**	1.943	1.440
7	**3.499**	2.998	**2.365**	1.895	1.415
8	**3.355**	2.896	**2.306**	1.860	1.397
9	**3.250**	2.821	**2.262**	1.833	1.383
10	**3.169**	2.764	**2.228**	1.812	1.372
11	**3.106**	2.718	**2.201**	1.796	1.363
12	**3.055**	2.681	**2.179**	1.782	1.356
13	**3.012**	2.650	**2.160**	1.771	1.350
14	**2.977**	2.624	**2.145**	1.761	1.345
15	**2.947**	2.602	**2.131**	1.753	1.341
16	**2.921**	2.583	**2.120**	1.746	1.337
17	**2.898**	2.567	**2.110**	1.740	1.333
18	**2.878**	2.552	**2.101**	1.734	1.330
19	**2.861**	2.539	**2.093**	1.729	1.328
20	**2.845**	2.528	**2.086**	1.725	1.325
21	**2.831**	2.518	**2.080**	1.721	1.323
22	**2.819**	2.508	**2.074**	1.717	1.321
23	**2.807**	2.500	**2.069**	1.714	1.319
24	**2.797**	2.492	**2.064**	1.711	1.318
25	**2.787**	2.485	**2.060**	1.708	1.316
26	**2.779**	2.479	**2.056**	1.706	1.315
27	**2.771**	2.473	**2.052**	1.703	1.314
28	**2.763**	2.467	**2.048**	1.701	1.313
29	**2.756**	2.462	**2.045**	1.699	1.311
30	**2.750**	2.457	**2.042**	1.697	1.310
31	**2.744**	2.453	**2.040**	1.696	1.309
32	**2.738**	2.449	**2.037**	1.694	1.309
34	**2.728**	2.441	**2.032**	1.691	1.307
36	**2.719**	2.434	**2.028**	1.688	1.306

Instructor note:

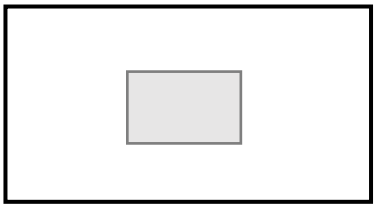
The preceding puzzle requires envelopes labeled with shapes – one correct answer and multiple decoys.

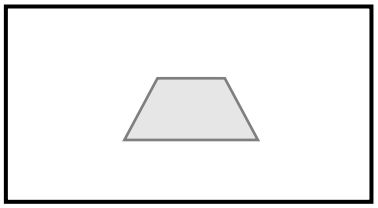
The incorrect envelopes can contain another t-table printout and a note to try again.





(Correct answer)





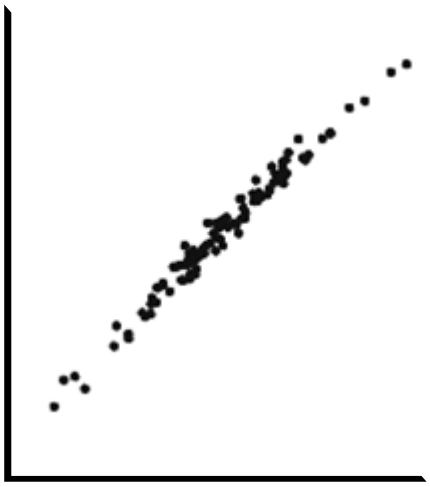
Which statistical test is appropriate?

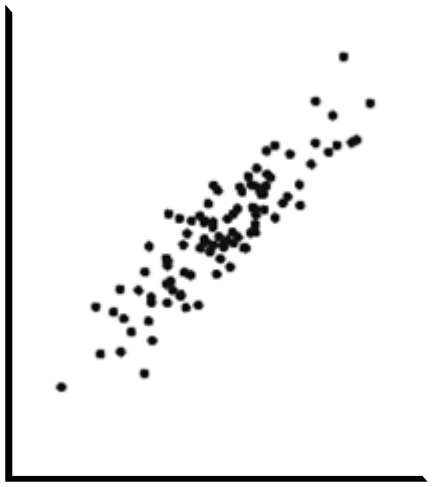
Comparing the number of season wins for the New England Patriots and the Los Angeles Rams	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Surveying children and their parents to compare their ratings of the home environment	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing students' GPA from Fall quarter to Winter quarter	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing customer satisfaction ratings for two different airlines	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing performance on a task for 50 participants, half in the control condition and half who received an adrenaline shot	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Measuring patients' blood sugar before and after they eat a meal	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing students' GPA across Fall, Winter, and Spring quarters	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing children's reading scores at the beginning and end of a school year	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing reading scores for a classroom of 3rd graders to a classroom of 5th graders	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing employee satisfaction at Company A and Company B	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance

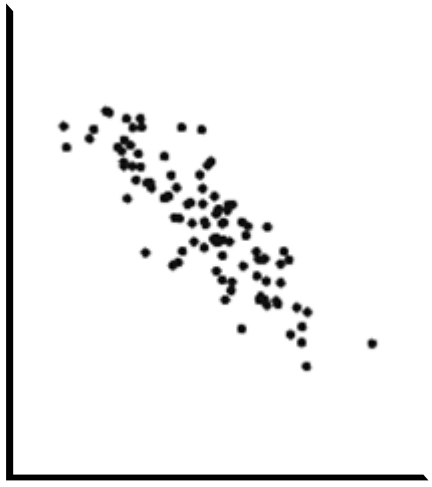
Code #:

Count # of independent t-tests:	
Count # of dependent t-tests:	
Count # of analyses of variance:	

r = 0.99	**r = 0.89**	**r = 0.66**	**r = 0.41**
r = -0.17	**r = -0.50**	**r = -0.67**	**r = -0.85**







ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9248.643	5	1849.729	9.725	.000
Within Groups	33094.386	174	190.198		
Total	42343.029	179			

Post Hoc Tests: Multiple Comparisons

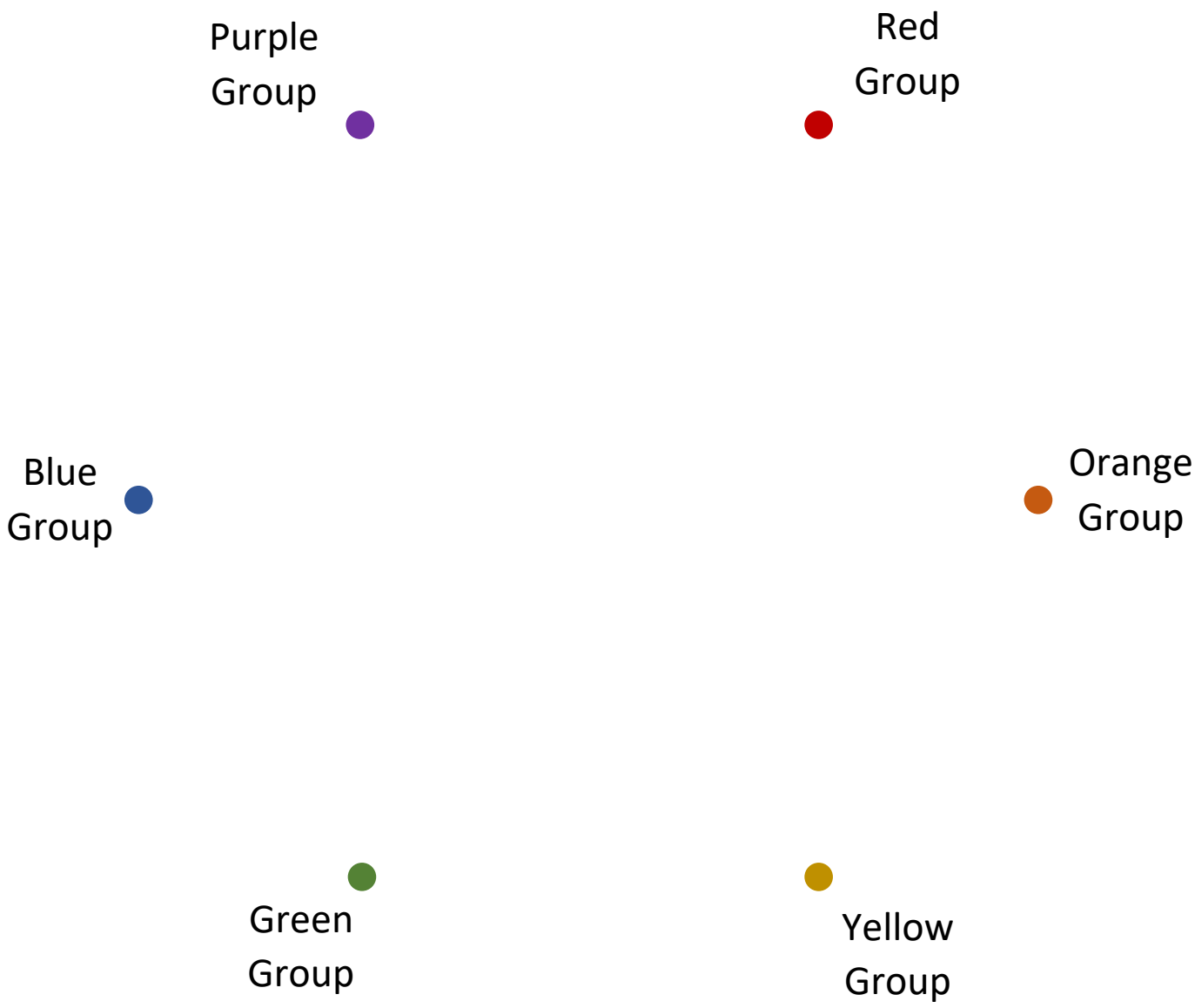
Dependent Variable: Score

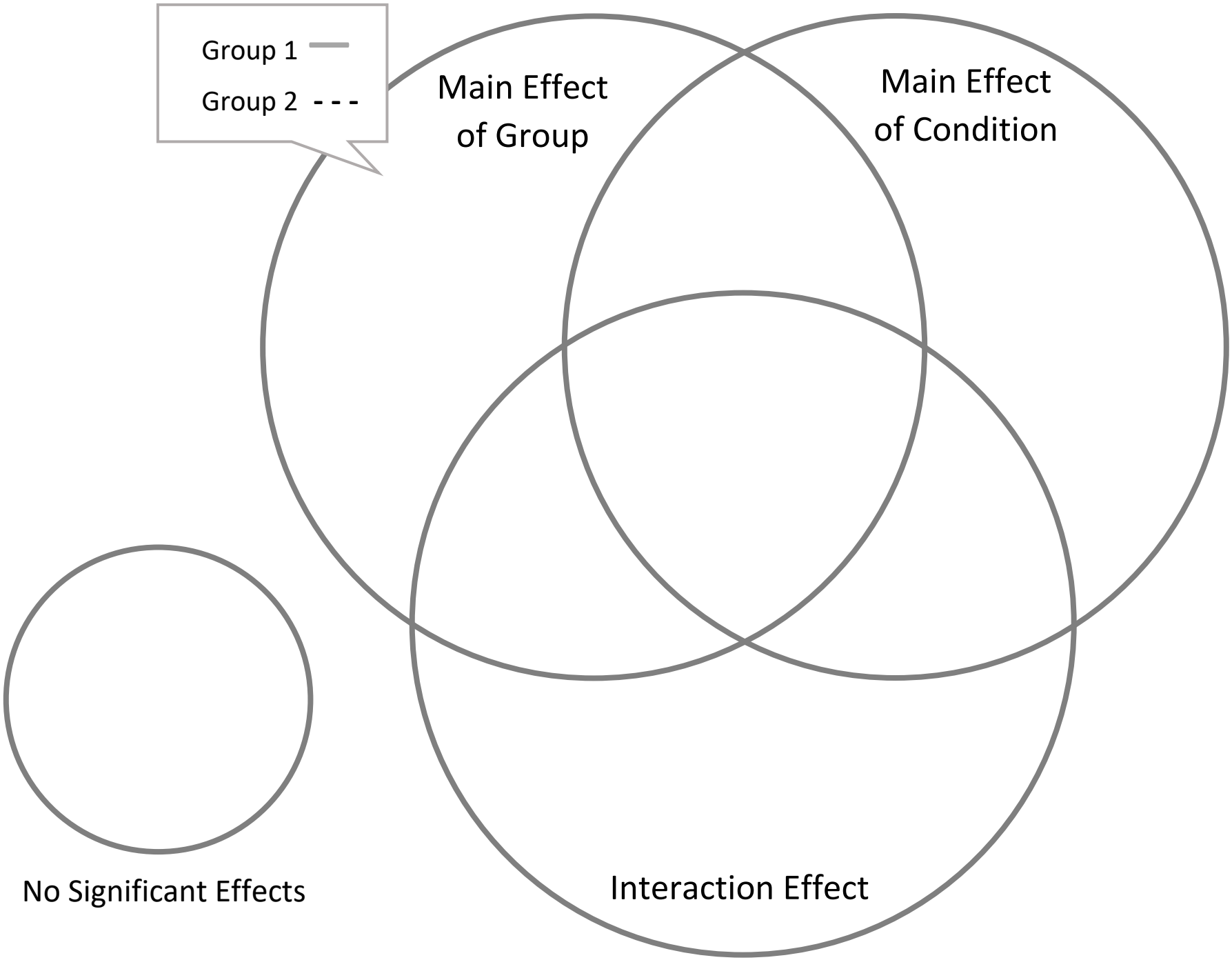
Tukey HSD

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Orange	Red	-8.62600	3.561	.154	-18.8875	1.6355
	Yellow	-3.89764	3.561	.883	-14.1592	6.3639
	Green	-13.38547	3.561	.003	-23.6470	-3.1239
	Purple	-12.46482	3.561	.008	-22.7264	-2.2033
	Blue	-22.31682	3.561	.000	-32.5784	-12.0553
Red	Orange	8.62600	3.561	.154	-1.6355	18.8875
	Yellow	4.72837	3.561	.769	-5.5332	14.9899
	Green	-4.75947	3.561	.764	-15.0210	5.5021
	Purple	-3.83882	3.561	.890	-14.1003	6.4227
	Blue	-13.69082	3.561	.002	-23.9524	-3.4293
Yellow	Orange	3.89764	3.561	.883	-6.3639	14.1592
	Red	-4.72837	3.561	.769	-14.9899	5.5332
	Green	-9.48783	3.561	.088	-19.7494	.7737
	Purple	-8.56718	3.561	.160	-18.8287	1.6943
	Blue	-18.41919	3.561	.000	-28.6807	-8.1577
Green	Orange	13.38547	3.561	.003	3.1239	23.6470
	Red	4.75947	3.561	.764	-5.5021	15.0210
	Yellow	9.48783	3.561	.088	-.7737	19.7494
	Purple	.92065	3.561	1.000	-9.3409	11.1822
	Blue	-8.93135	3.561	.127	-19.1929	1.3302
Purple	Orange	12.46482	3.561	.008	2.2033	22.7264
	Red	3.83882	3.561	.890	-6.4227	14.1003
	Yellow	8.56718	3.561	.160	-1.6943	18.8287
	Green	-.92065	3.561	1.000	-11.1822	9.3409
	Blue	-9.85200	3.561	.068	-20.1135	.4095

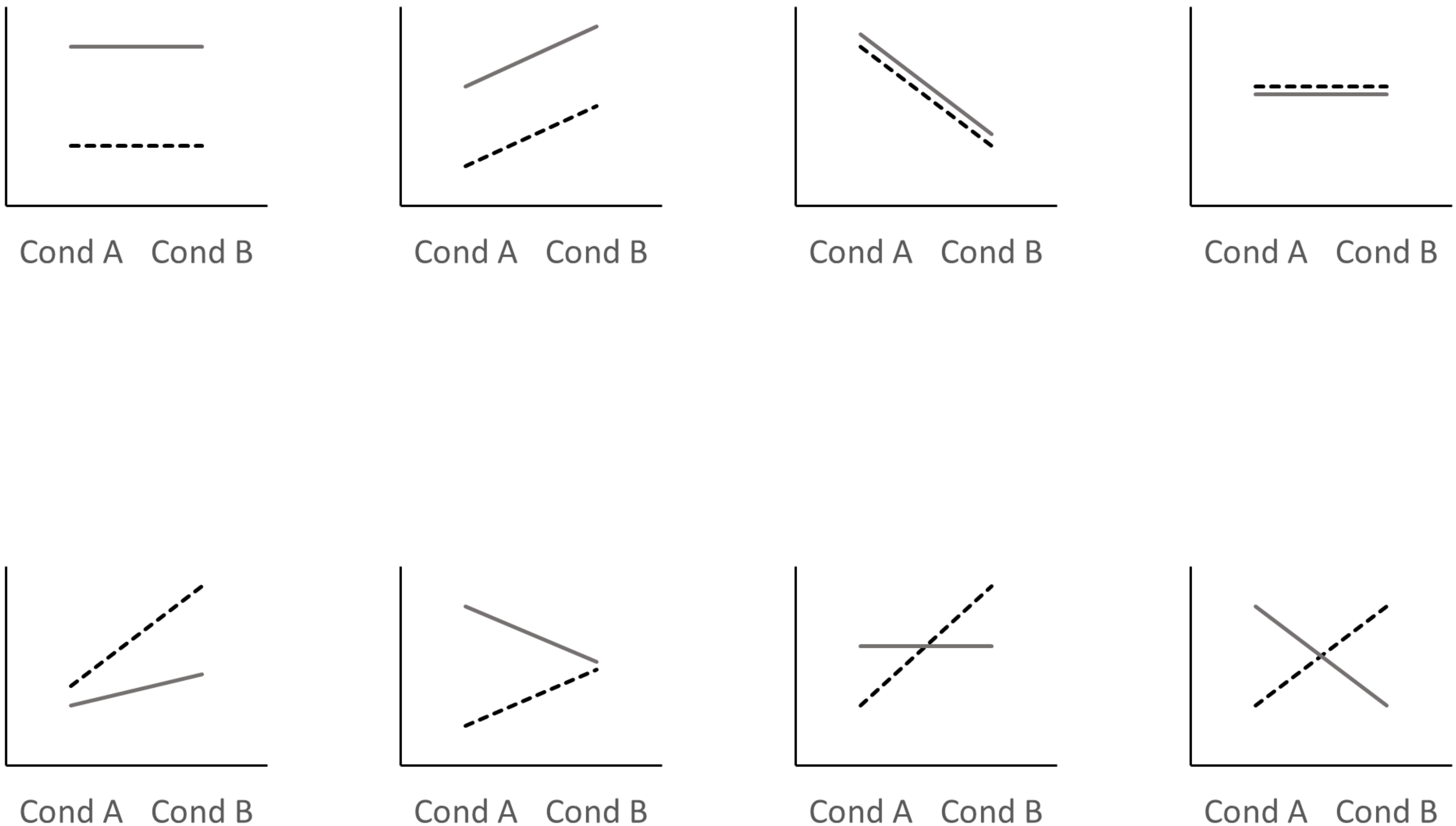
A one-way ANOVA was conducted to test differences between six groups, each with 30 participants.

Create a design from the post hoc comparisons by **drawing a line** between each pair of groups that are significantly different ($\alpha = .05$).




Group 1
Group 2
Main Effect of Group
Main Effect of Condition
No Significant Effects
Interaction Effect

Puzzle N


Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B

One-sample test = O

T-test = T

Analysis of Variance = A

Correlation = C

Regression = R

	Which test?
Can height be predicted using body weight and shoe size?	
Is there a relationship between happiness and social media use?	
Do smokers have higher blood pressure than non-smokers?	
Does School A's mean standardized test score differ from the state average?	
Do age and length of driving experience explain number of speeding tickets?	
Does memory capacity differ between 9-year-olds, 10-year-olds, and 11-year-olds?	

Unscramble

____ ____ ____ ____ ____ ____

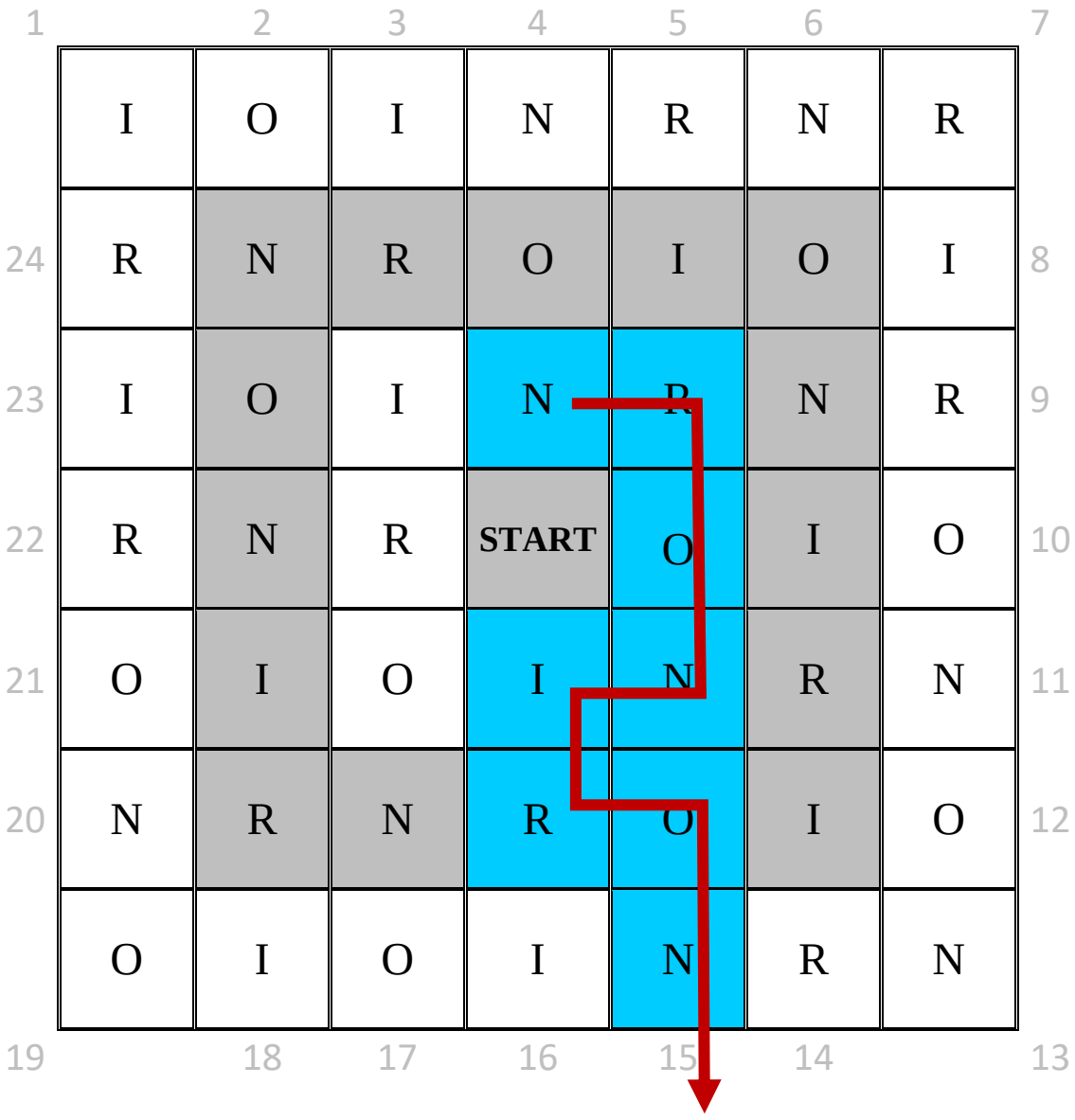
Goal: Escape from the grid by finding the correct path to the outside ring

Rules: From the **START** position, you will make 8 moves

You can move within a ring or move closer to the outside

You can move to adjacent squares, but not diagonally

You cannot re-enter a ring to move back toward the center

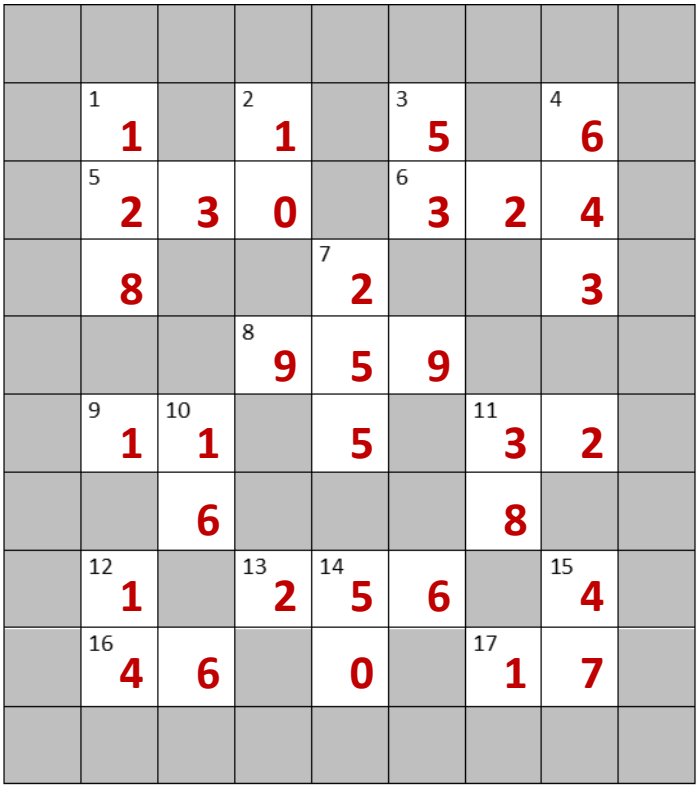


Where did you exit the grid? Square # **15**

N = Nominal variable
O = Ordinal variable
I = Interval variable
R = Ratio variable

Which level of measurement?

1st move	Eye color (brown, blue, green, etc.)	**N**
2nd move	Annual salary (in $)	**R**
3rd move	Olympic medal (gold, silver, bronze)	**O**
4th move	Academic major (psychology, history, chemistry, etc.)	**N**
5th move	IQ score (120, 90, 140, etc.)	**I**
6th move	Distance travelled (in meters)	**R**
7th move	Level of education (high school, bachelor's, master's, etc.)	**O**
8th move	Favorite music genre (pop, country, rock, etc.)	**N**

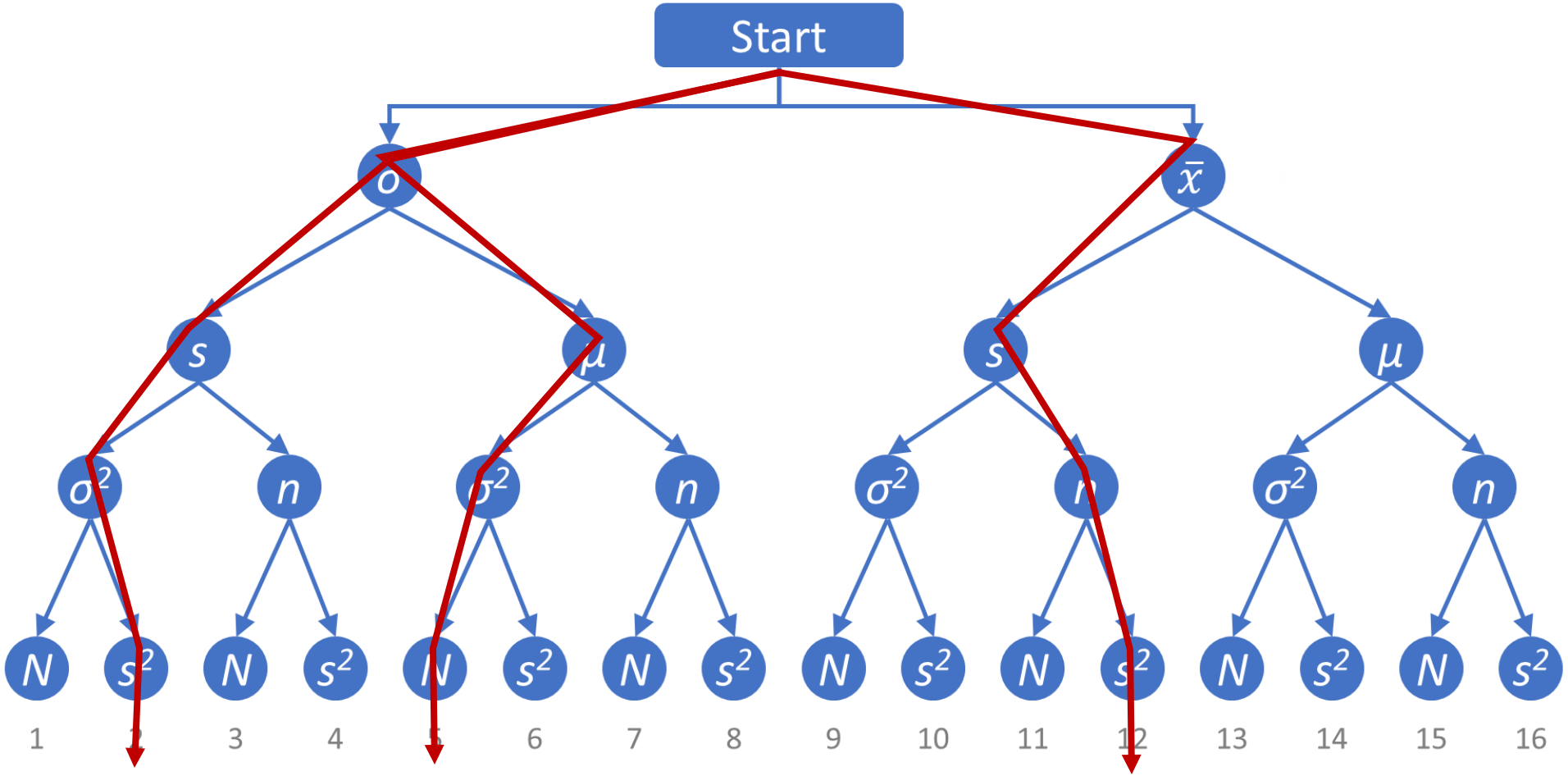


Down

1. Mean of 155, 120, 77, 106, 182
2. Mode of 25, 15, 10, 15, 10, 25, 10
3. Mean of 60, 56, 44, 45, 54, 59, 53
4. Median of 867, 473, 531, 122, 755, 804
7. Median of 372, 105, 986, 264, 246, 139
10. Mode of 20, 22, 16, 16, 14, 19
11. Mean of 26, 53, 37, 24, 37, 51
12. Median of 18, 12, 14, 16, 14, 19, 11
14. Mean of 0, 0, 0, 25, 75, 200
15. Mode of 51, 47, 53, 48, 47

Across

5. Median of 280, 160, 230, 310, 100
6. Median of 490, 80, 357, 291, 541, 280
8. Mode of 959, 595, 959, 595, 959
9. Mode of 11, 15, 31, 11, 23
11. Mean of 30, 31, 32, 33, 34
13. Mode of 157, 256, 0, 177, 256
16. Median of 100, 2, 15, 37, 73, 55
17. Mean of 11, 17, 21, 17, 18, 18



Following the symbols that represent **sample** statistics leads to path #: **12**

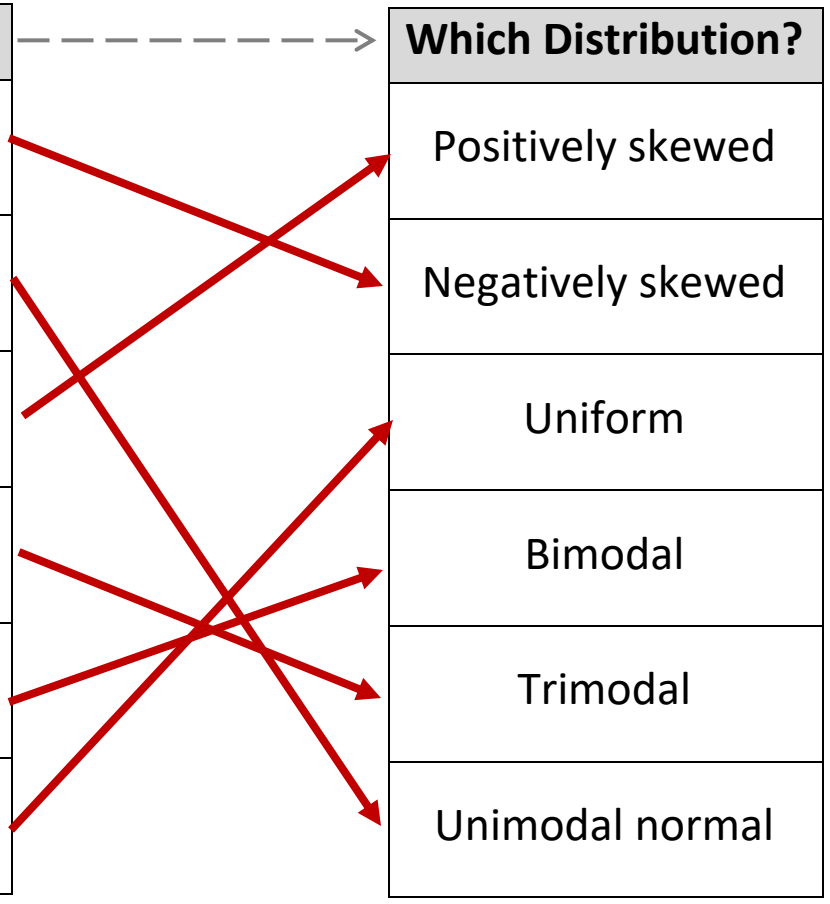
Following the symbols that represent measures of **variability** leads to path #: **2**

Following the symbols that represent **population** parameters leads to path #: **5**

Match each set of sample values to its frequency distribution

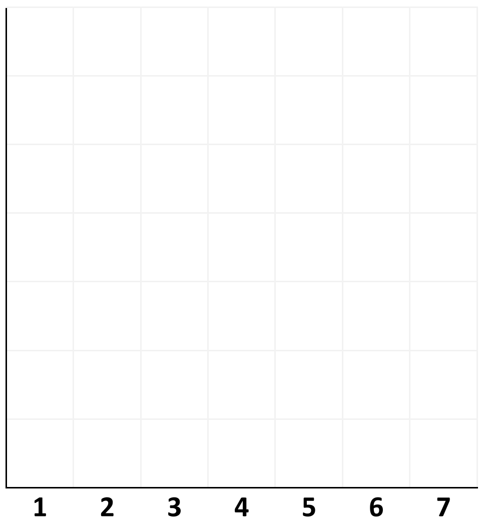
(You can use the blank charts to help visualize the samples)

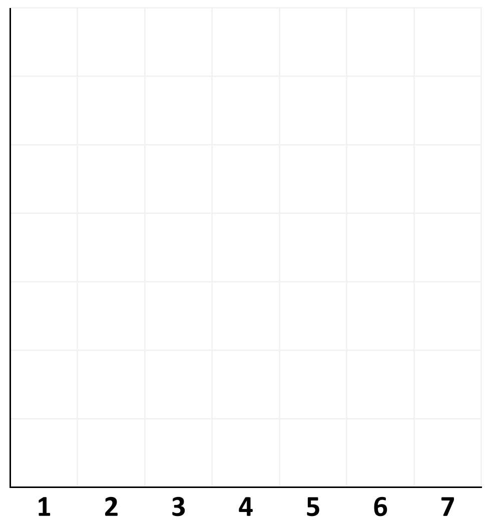
Sample	Sample values (*n* = 16)
A	6, 4, 1, 5, 5, 6, 7, 7, 3, 4, 6, 5, 5, 2, 3, 4
B	6, 3, 7, 5, 2, 2, 5, 6, 3, 4, 4, 3, 5, 4, 4, 1
C	2, 5, 4, 4, 3, 6, 3, 6, 3, 1, 1, 2, 2, 1, 5, 1
D	2, 4, 7, 4, 7, 1, 6, 1, 2, 4, 1, 7, 5, 1, 4, 7
E	6, 4, 5, 2, 6, 6, 1, 2, 7, 2, 3, 5, 2, 4, 1, 6
F	2, 4, 5, 4, 4, 2, 3, 5, 3, 2, 3, 2, 4, 5, 3, 5

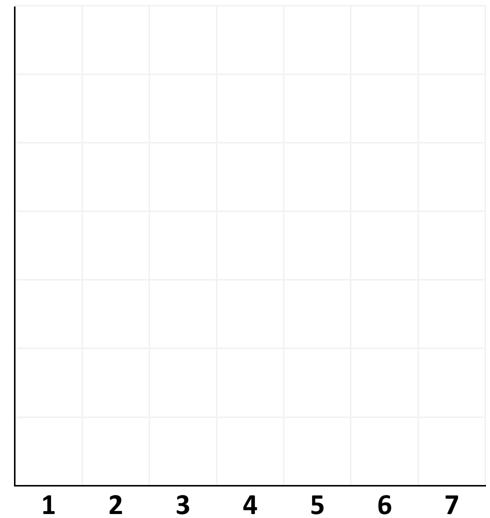


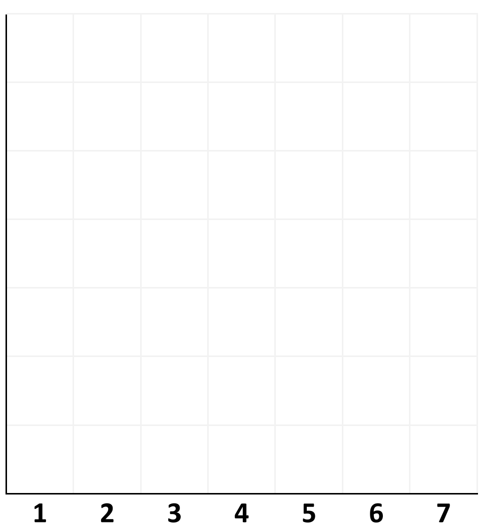
Which Distribution?
Positively skewed
Negatively skewed
Uniform
Bimodal
Trimodal
Unimodal normal

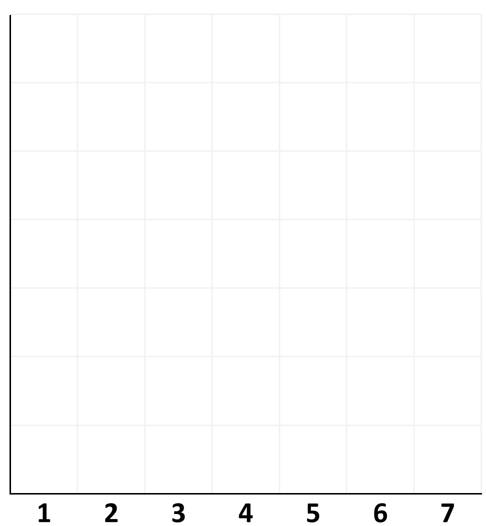
Puzzle D

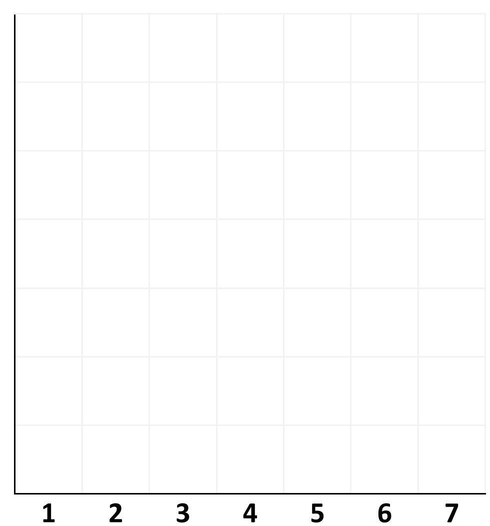




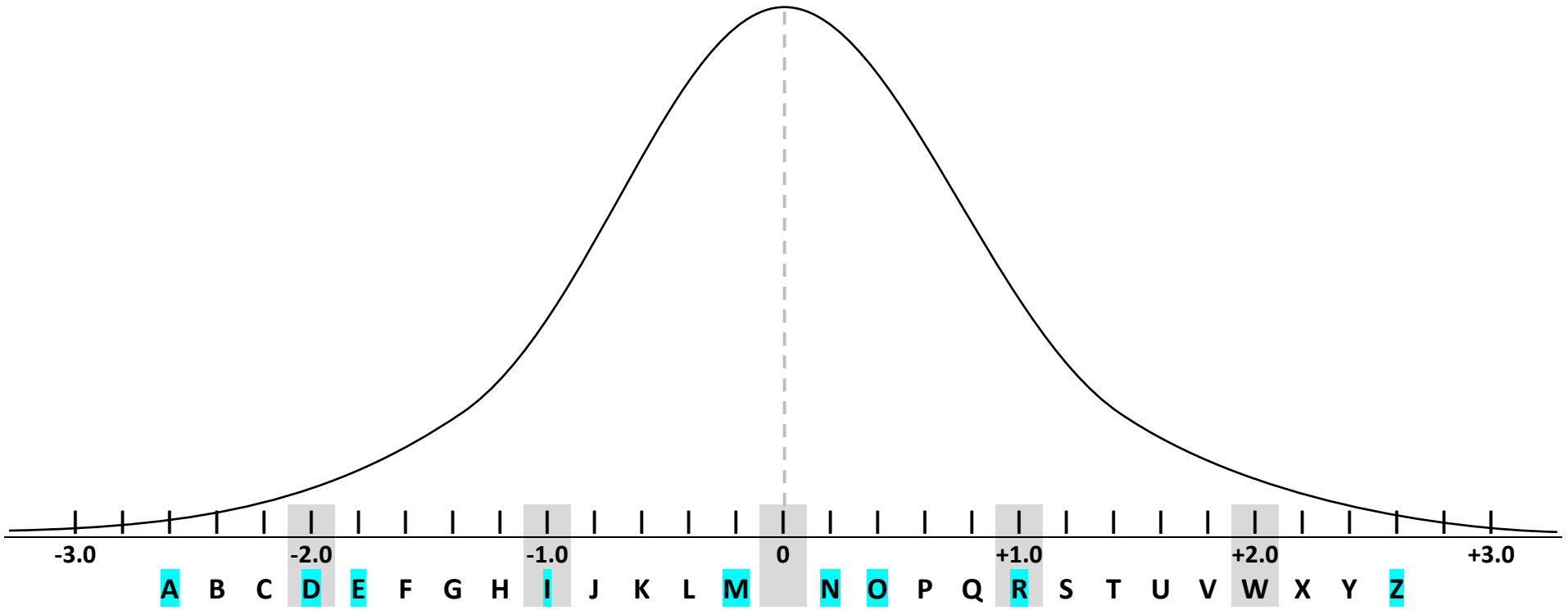








Puzzle E



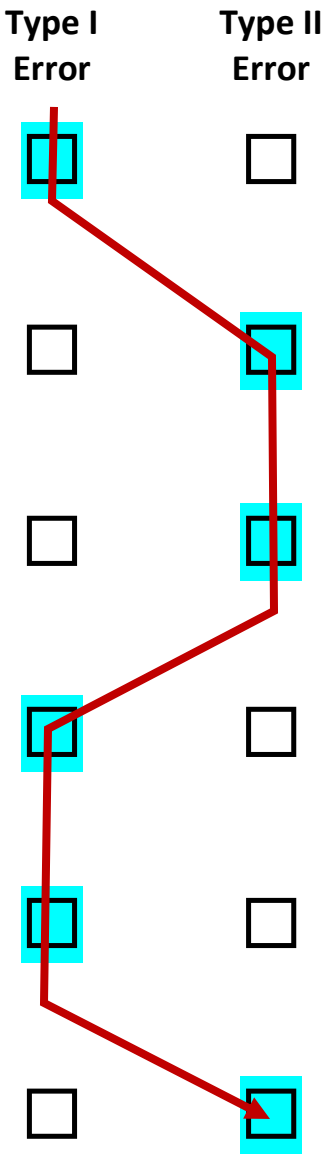
Code word: R A N D O M I Z E

#	Raw Score	Z-Score
1	The average number of steps people walk per day is 5,000 (SD = 1,000 steps). Amy walks 6,000 steps.	1.0 = R
2	The mean height of American men is 5'9" (69 inches), with a standard deviation of 3 inches. Bob is 61.2 inches tall.	-2.6 = A
3	A company manufactures products that weigh 350 grams (SD = 5 grams). A customer receives a product that weighs 351 grams.	0.2 = N
4	An average bag of candy contains 60 pieces (SD = 3 pieces). Derek buys a bag of candy that contains 54 pieces.	-2.0 = D
5	A new car model has an average fuel economy of 43 miles per gallon and a standard deviation of 1.5 MPG. A test-driven vehicle gets 43.6 MPG.	0.4 = O
6	The average salary at a company is $45,600 (SD = $6,700). A specific employee makes $44,260.	-0.2 = M
7	The average house in a neighborhood has 3.5 bedrooms (SD = 1.5 bedrooms). One family's house has 2 bedrooms.	-1.0 = I
8	A class takes an exam with an average score of 78% (SD = 7%). Maria's exam score is 96.2%	2.6 = Z
9	The average cup of coffee contains 95 mg of caffeine, with a standard deviation of 15 mg. Dan's cup contains 68 mg of caffeine.	-1.8 = E

Type	Hyp. 1	Hyp. 2	Hyp. 3	Hyp. 4	Hyp. 5	Hyp. 6	Hyp. 7	Hyp. 8
Non-directional Null	H	A	G	E	L	F	O	D
Directional Null	P	I	W	O	E	R	A	N
Non-directional Alternative	T	E	L	U	R	D	U	R
Directional Alternative	B	O	E	A	P	L	E	L

Code Word: P O W E R F U L

Hypothesis 1	Age is unrelated or positively related to memory performance
Hypothesis 2	A new medication improves patients' symptoms
Hypothesis 3	The treatment group will not perform better than the control group
Hypothesis 4	Attending tutor sessions does not affect students' grades
Hypothesis 5	Noise level will influence customer satisfaction
Hypothesis 6	Daily temperature is unrelated to urban crime rates
Hypothesis 7	Education level has an effect on household income
Hypothesis 8	A proposed law will decrease traffic accidents



A pharmacologist concludes that a new depression drug is an effective treatment, but it actually does nothing

An economist predicts that a company's stock will be stable, but the stock skyrockets

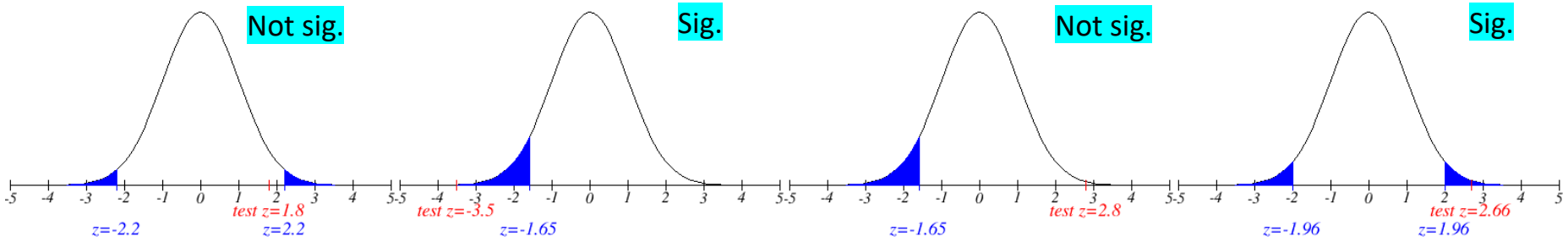
A water treatment plant determines that a water source is safe to drink, but the water is toxic

An economist predicts that a company's stock will skyrocket, but the stock does not change

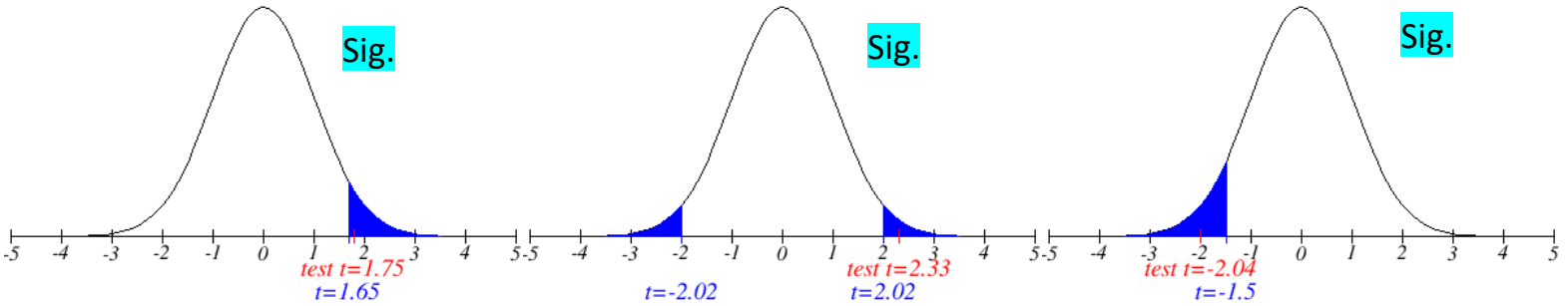
A water treatment plant determines that a water source is toxic, but the water is safe to drink

A pharmacologist concludes that a new depression drug is ineffective, but it actually reduces depression symptoms

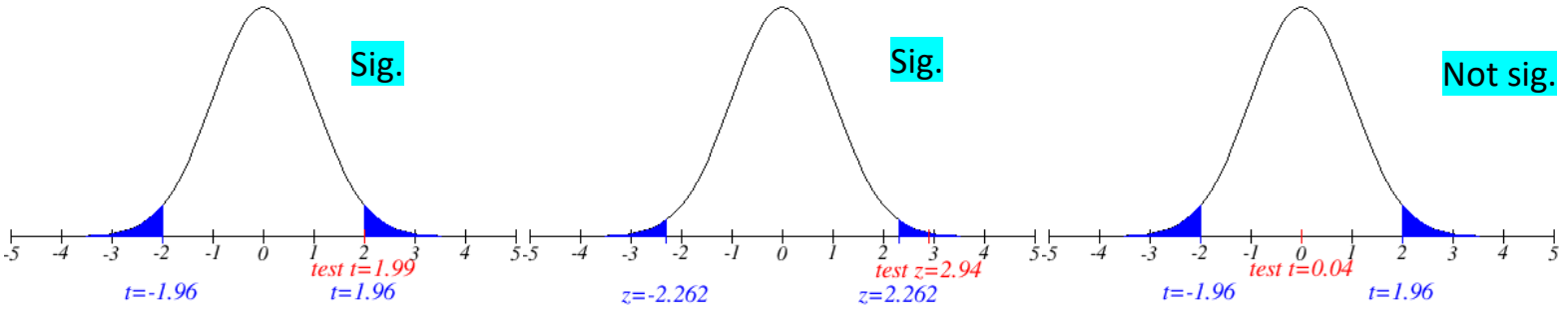
1


Not sig.
test z=1.8
z=-2.2
z=2.2
Sig.
test z=-3.5
z=-1.65
Not sig.
test z=2.8
z=-1.65
Sig.
test z=2.66
z=-1.96
z=1.96

2


Sig.
test t=1.75
t=1.65
Sig.
test t=2.33
t=-2.02
t=2.02
Sig.
test t=-2.04
t=-1.5

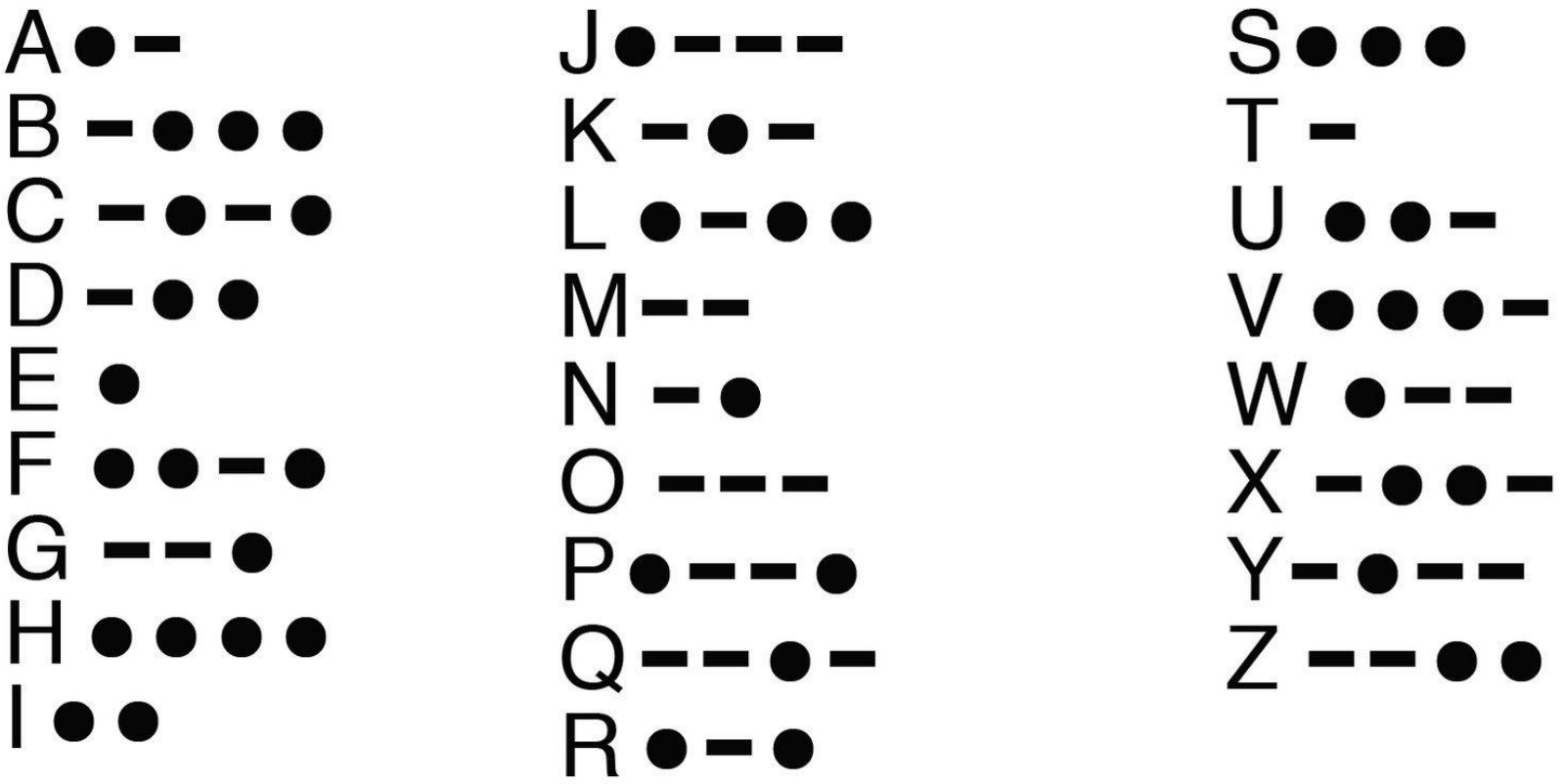
3


Sig.
test t=1.99
t=-1.96
t=1.96
Sig.
test z=2.94
z=-2.262
z=2.262
Not sig.
test t=0.04
t=-1.96
t=1.96

___C___	___S___	___U___
1	2	3

Significant ●

Not Significant —



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

	df	Code
Comparing health for 20 cancer patients before and after treatment	19	**S**
Comparing IQ of 12 women and 10 men	20	**T**
Comparing life expectancy in 1910 and 2010 for two countries	1	**A**
Comparing marital satisfaction in 21 couples (42 spouses total)	20	**T**
Comparing blood pressure in 6 vegans and 15 meat-eaters	19	**S**

Connect the critical values for the tests below
to create a **shape** on your t-table

Independent t-test comparing two groups of N = 16 each, two-tailed α = .02

Df = 30

(N = 32 – 2 = 30)

Dependent t-test with 31 pairs of participants, one-tailed α = .05

Df = 30

(N = 31 pairs – 1 = 30)

Independent t-test comparing two groups that each have 12 participants, one-tailed α = .025

Df = 22

(N = 24 – 2 = 22)

Dependent t-test with 46 spouses analyzed in pairs, two-tailed α = .20

Df = 22

(N = 23 pairs – 1 = 22)

Once you have identified the shape,
open the corresponding envelope!

TABLE A-3 *t* Distribution: Critical *t* Values

	Area in One Tail				
	0.005	0.01	0.025	0.05	0.10
Degrees of Freedom	Area in Two Tails				
	0.01	0.02	0.05	0.10	0.20
1	**63.657**	31.821	**12.706**	6.314	3.078
2	**9.925**	6.965	**4.303**	2.920	1.886
3	**5.841**	4.541	**3.182**	2.353	1.638
4	**4.604**	3.747	**2.776**	2.132	1.533
5	**4.032**	3.365	**2.571**	2.015	1.476
6	**3.707**	3.143	**2.447**	1.943	1.440
7	**3.499**	2.998	**2.365**	1.895	1.415
8	**3.355**	2.896	**2.306**	1.860	1.397
9	**3.250**	2.821	**2.262**	1.833	1.383
10	**3.169**	2.764	**2.228**	1.812	1.372
11	**3.106**	2.718	**2.201**	1.796	1.363
12	**3.055**	2.681	**2.179**	1.782	1.356
13	**3.012**	2.650	**2.160**	1.771	1.350
14	**2.977**	2.624	**2.145**	1.761	1.345
15	**2.947**	2.602	**2.131**	1.753	1.341
16	**2.921**	2.583	**2.120**	1.746	1.337
17	**2.898**	2.567	**2.110**	1.740	1.333
18	**2.878**	2.552	**2.101**	1.734	1.330
19	**2.861**	2.539	**2.093**	1.729	1.328
20	**2.845**	2.528	**2.086**	1.725	1.325
21	**2.831**	2.518	**2.080**	1.721	1.323
22	**2.819**	2.508	2.074	1.717	1.321
23	**2.807**	2.500	2.069	1.714	1.319
24	**2.797**	2.492	2.064	1.711	1.318
25	**2.787**	2.485	2.060	1.708	1.316
26	**2.779**	2.479	2.056	1.706	1.315
27	**2.771**	2.473	2.052	1.703	1.314
28	**2.763**	2.467	2.048	1.701	1.313
29	**2.756**	2.462	2.045	1.699	1.311
30	**2.750**	2.457	2.042	1.697	1.310
31	**2.744**	2.453	2.040	1.696	1.309
32	**2.738**	2.449	2.037	1.694	1.309
34	**2.728**	2.441	2.032	1.691	1.307
36	**2.719**	2.434	2.028	1.688	1.306

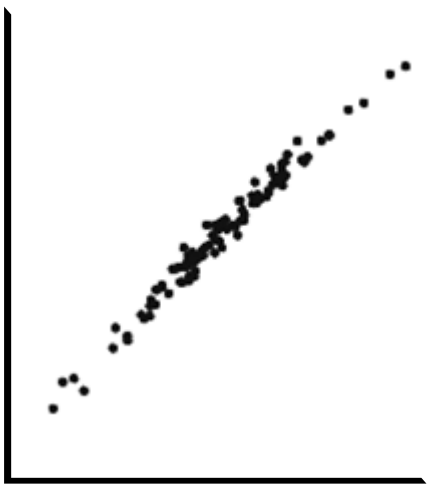
Which statistical test is appropriate?

Comparing the number of season wins for the New England Patriots and the Los Angeles Rams	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Surveying children and their parents to compare their ratings of the home environment	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing students' GPA from Fall quarter to Winter quarter	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing customer satisfaction ratings for two different airlines	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing performance on a task for 50 participants, half in the control condition and half who received an adrenaline shot	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Measuring patients' blood sugar before and after they eat a meal	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing students' GPA across Fall, Winter, and Spring quarters	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing children's reading scores at the beginning and end of a school year	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing reading scores for a classroom of 3rd graders to a classroom of 5th graders	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance
Comparing employee satisfaction at Company A and Company B	☐ Independent T-Test ☐ Dependent T-Test ☐ Analysis of Variance

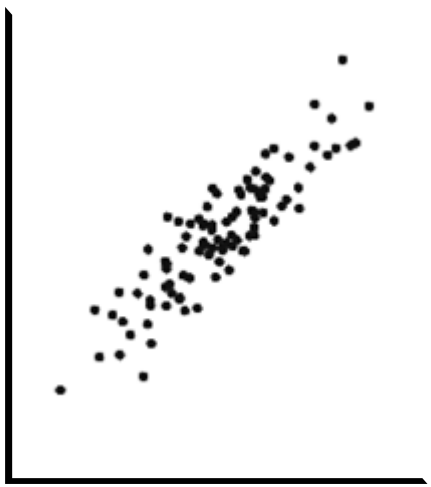
Code #:

Count # of independent t-tests:	**5**
Count # of dependent t-tests:	**4**
Count # of analyses of variance:	**1**

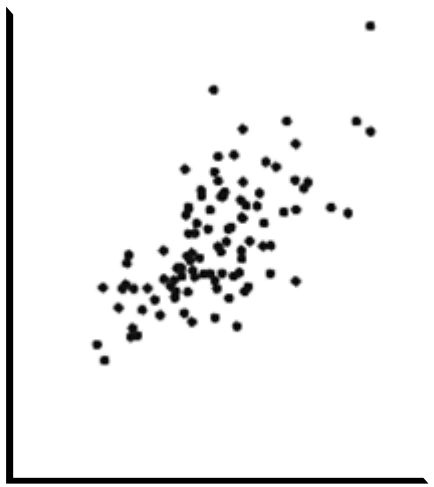
Puzzle L



r = 0.99



r = 0.89



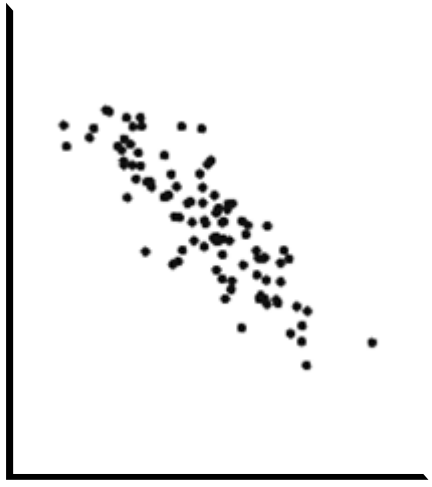
r = 0.66

r = 0.41

r = -0.17

r = -0.50

r = -0.67



r = -0.85

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9248.643	5	1849.729	9.725	.000
Within Groups	33094.386	174	190.198		
Total	42343.029	179			

Post Hoc Tests: Multiple Comparisons

Dependent Variable: Score

Tukey HSD

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Orange	Red	-8.62600	3.561	.154	-18.8875	1.6355
	Yellow	-3.89764	3.561	.883	-14.1592	6.3639
	Green	-13.38547	3.561	.003	-23.6470	-3.1239
	Purple	-12.46482	3.561	.008	-22.7264	-2.2033
	Blue	-22.31682	3.561	.000	-32.5784	-12.0553
Red	Orange	8.62600	3.561	.154	-1.6355	18.8875
	Yellow	4.72837	3.561	.769	-5.5332	14.9899
	Green	-4.75947	3.561	.764	-15.0210	5.5021
	Purple	-3.83882	3.561	.890	-14.1003	6.4227
	Blue	-13.69082	3.561	.002	-23.9524	-3.4293
Yellow	Orange	3.89764	3.561	.883	-6.3639	14.1592
	Red	-4.72837	3.561	.769	-14.9899	5.5332
	Green	-9.48783	3.561	.088	-19.7494	.7737
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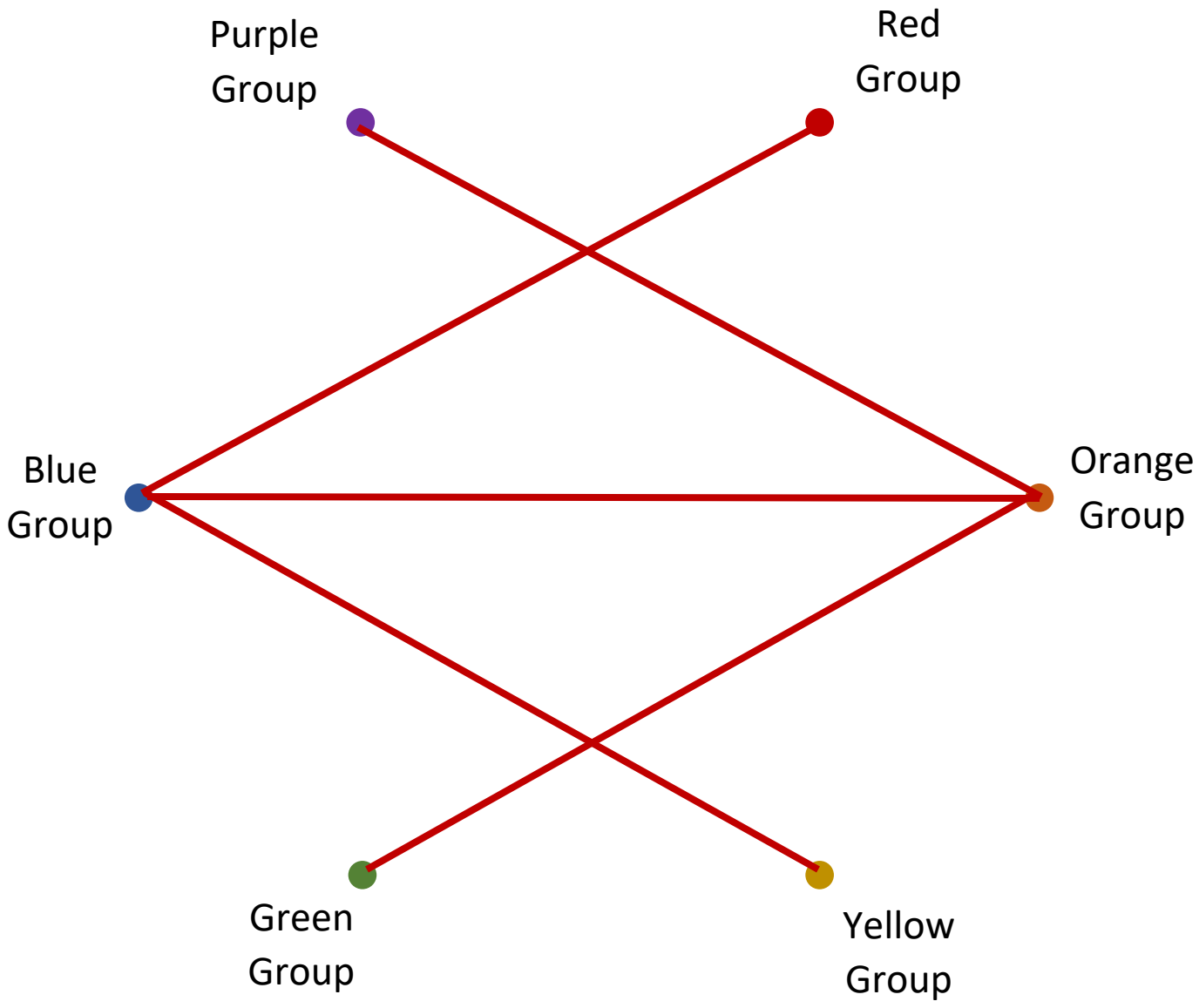
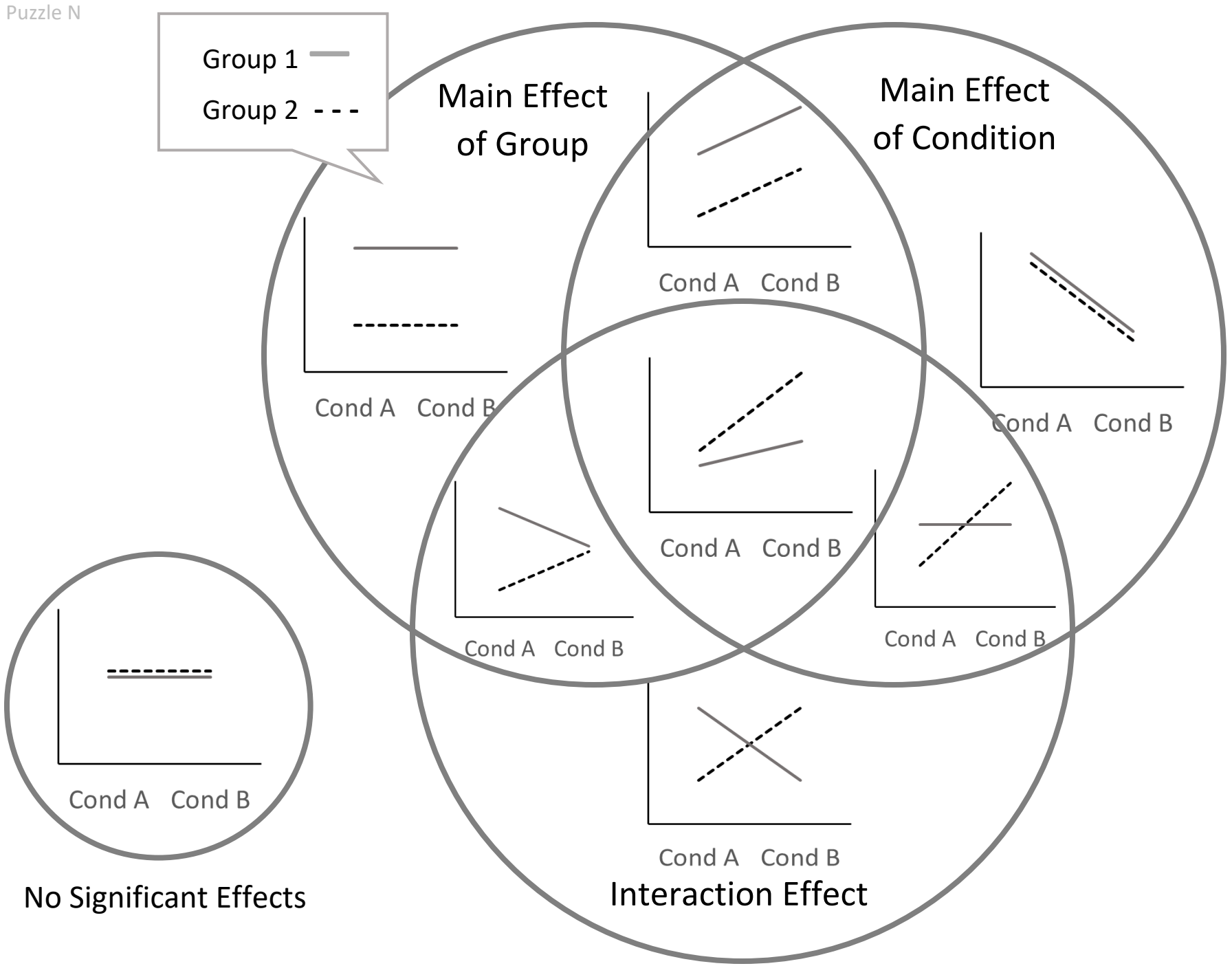
	Blue	-18.41919	3.561	.000	-28.6807	-8.1577
Green	Orange	13.38547	3.561	.003	3.1239	23.6470
	Red	4.75947	3.561	.764	-5.5021	15.0210
	Yellow	9.48783	3.561	.088	-.7737	19.7494
	Purple	.92065	3.561	1.000	-9.3409	11.1822
	Blue	-8.93135	3.561	.127	-19.1929	1.3302
Purple	Orange	12.46482	3.561	.008	2.2033	22.7264
	Red	3.83882	3.561	.890	-6.4227	14.1003
	Yellow	8.56718	3.561	.160	-1.6943	18.8287
	Green	-.92065	3.561	1.000	-11.1822	9.3409
	Blue	-9.85200	3.561	.068	-20.1135	.4095

A one-way ANOVA was conducted to test differences between six groups, each with 30 participants.

Create a design from the post hoc comparisons by **drawing a line** between each pair of groups that are significantly different (α = .05).



Puzzle N


Group 1
Group 2
Main Effect of Group
Main Effect of Condition
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
Cond A Cond B
No Significant Effects
Interaction Effect

One-sample test = O

T-test = T

Analysis of Variance = A

Correlation = C

Regression = R

	Which test?
Can height be predicted using body weight and shoe size?	R
Is there a relationship between happiness and social media use?	C
Do smokers have higher blood pressure than non-smokers?	T
Does School A's mean standardized test score differ from the state average?	O
Do age and length of driving experience explain number of speeding tickets?	R
Does memory capacity differ between 9-year-olds, 10-year-olds, and 11-year-olds?	A

Unscramble

C A R R O T